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AUTHOR Dyer, James S.
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ABSTRACT

This paper presents a methodology for the analysis of the effects of changes in the cost of higher education to the student. It considers first the importance of the cost in higher education in determining whether or not a potential, qualified student will actually enroll. Methods are then illustrated for estimating the student's ability to pay and the cost of higher education to the student. Comparisons of the ability to pay and the cost factors provide estimates of the percentage of potential students who are effectively "priced out" of higher education. This approach may be used by public or private institutions to study proposed changes in tuition or scholarship policies. The techniques can also be applied to the analysis of the problem of whether to expand existing physical facilities to provide for growing enrollments, or establish new institutions in heavily populated urban centers. (Author/AF)

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James S. Dyer

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ASSESSING THE EFFECTS OF CHANGES IN THE COST OF HIGHER EDUCATION TO THE STUDENT

James S. Dyer*

The Rand Corporation, Santa Monica, California

This paper will present a methodology for the analysis of the effects of changes in the cost of higher education to the student. The importance of the cost of higher education in determining whether or not a potential, qualified student will actually enroll will first be considered. Methods for estimating the student's ability to pay and the cost of higher education to the student will then be illustrated. Comparisons of these two factors will be seen to provide estimates of the percentage of potential students who are effectively "priced out" of higher education. This approach may be used by public or private institutions to study proposed changes in tuition or scholarship policies. Less obviously, these techniques can also be applied to the analysis of the problem of whether to expand existing physical facilities to provide for growing enrollments, or to establish new institutions in heavily populated urban centers.**

The enrollment in higher education contains a disproportionately large number of persons from the upper and middle classes of American society. Jencks and Riesman discuss this phenomena in some detail in their study of higher education in American, The Academic Revolution.*** They suggest three possible explanations: economic factors, entrance requirements that discriminate on a cultural basis, and motivational factors. They seem to discount the economic factor on the basis that studies have shown that the very gifted among the lower socioeconomic classes do manage to find some way to afford the costs of higher education. The alleged discrimination of entrance requirements is also discredited, as the tests have been shown to do a relatively good job in

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**Such an analysis is developed in James S. Dyer, Cost-Effectiveness Analysis for a Public System of Higher Education, (unpublished Ph.D. dissertation, The University of Texas at Austin, 1969).

***For a complete discussion, see the third chapter of Christopher Jencks and David Riesman, The Academic Revolution, (Garden City, New York: Doubleday and Company, Inc., 1968).

indicating the actual potential of an individual for academic success. "Those who look askance at testing should not, then, rest their case on the simple notion that tests are 'unfair to the poor.' Life is unfair to the poor. Tests merely measure the results."* Thus, the authors conclude that the major cause of the failure of individuals from the lower socioeconomic classes of American society to attend institutions of higher education in proportional numbers is a lack of motivation. This lack is largely the result of the low priority placed on higher education by the parents and peer groups of these youths.

However, Jencks and Riesman may be underestimating the economic factors in the decision of the individuals of lower socioeconomic classes not to attend institutions of higher education. Given that the motivation for education in this group is indeed lower, the amount of sacrifice that an individual would be willing to make to participate in higher education would also be expected to be lower. In addition, since the families in these social classes have, by definition, a lower discretionary income, the cost of higher education must represent a relatively greater sacrifice than to the other members of American society. These two reinforcing factors offer a reasonable explanation for the fact that only the very gifted youths from the lower socioeconomic classes are willing to make the required financial sacrifices; the returns of higher education are greater for those of exceptional abilities, and the risk of failure is lower.

THE COST OF HIGHER EDUCATION TO THE STUDENT AS A DETERMINANT OF ENROLLMENT

This section will consider the impact of the cost of higher education on enrollment, and will provide an introduction to the material which follows.

Several recent studies have appeared which deal with the identification of the factors which determine the probability that an individual will attend an institution of higher education.** For convenience of

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*Ibid., p. 125

**See the bibliography associated with John Conlisk, "Determinants of School Enrollment and School Performance," Journal of Human Resources (Spring 1969), pp. 140-57.

analysis, these factors may be dichotomized into two broad classes. The resulting expression may be written as

$$P(E) = f_1(AP, NE) \tag{1}$$

where P(E) is defined as the probability that a potential student will enroll in the system, AP is defined as a measure of the student's "ability to pay" for higher education, and NE is defined as a measure of the "noneconomic factors" which influence the individual. The potential student's "ability to pay," AP, may be described as

$$AP = f_2(I, F, S, r_1) \tag{2}$$

where I is defined as family income, F as family size, S as the availability of scholarships, loans, and part-time employment, and r_1 represents random or otherwise unspecified factors. Similarly, NE may be described as

$$NE = f_3(R_a, R_e, U, P, A, r_2) \tag{3}$$

where R_a is defined as race, R_e as religion, U as urban or nonurban environment, P as parent's and peer's level of educational achievement and/or expectation, A as a measure of the individual's ability and motivation, and r_2 is analogous to r_1.

Noneconomic factors are a particularly important consideration when dealing with questions relating to the effects of educational programs on specific segments of society. However, when dealing with an aggregate population, these factors are relatively less important, as they will tend to balance out. In addition, the effects of these noneconomic factors may be implied from empirical data relating to economic questions. For example, different enrollment patterns from different segments of society with equivalent income and family size parameters should reveal the strength of these considerations. Nevertheless, the description of the methodology which follows will not be concerned with estimating these noneconomic effects, and, thus,

implicitly assumes that they are included in the required data, much of which may be obtained empirically. However, similar studies with respect to special groups, such as nonwhites, should be designed to adjust for the possibility of a significant, noneconomic bias.

Expression (2) for "ability to pay" may be simplified by assuming that the average contribution that a potential student could make from scholarships, loans, and part-time employment is independent from family size and income. Although many scholarship plans and loans are related to family income, this assumption may be reasonable over the range of costs relevant to an analysis. In addition, instead of the vague "ability to pay," attention will be focused on EC, the expected total contribution to the cost of higher education by a potential student. The expression for EC may be written as

$$EC = f_4(I, F) + s, \tag{4}$$

where s is an estimate of average contribution from scholarships, loans, part-time employment, and other sources. The factors represented by r_1 will be ignored. For a specific family size, the expected contribution could be expressed solely as a function of family income. In such a case, a transformation of the distribution of incomes among these families of potential students would provide an approximation to the distribution of expected contribution to the cost of higher education within the group.

There are several distribution functions which might be considered as statistical descriptions of income distributions, including the Pareto and lognormal. Aitchison and Brown have suggested the following criteria for the selection of such a function:

(i) How closely does the description approximate to the observed distribution of incomes when specific values are assigned to the parameters? These values will usually be estimated from the data.

(ii) To what extent may the statistical description be shown to rest on assumptions which are consistent with our knowledge of the ways in which incomes are generated?

(iii) What facilities does the description provide in the statistical analysis of the data?

(iv) What economic meaning or significance can be attached to the parameters of the description?*

On the basis of these criteria, they suggested the lognormal distribution as a reasonable compromise.

The lognormal distribution of the random variable X has the property that the random variable Y = log X has a normal distribution with mean μ and variance σ^2. The specific form of the lognormal distribution function, F(x), is given by

$$F(x) = \begin{cases} 0, & x \leq 0 \\ \int_0^x \frac{1}{t\sigma\sqrt{2\pi}} \exp\left\{-\frac{1}{2\sigma^2}(\log t - u)^2\right\} dt, & x > 0. \end{cases} \tag{5}$$

The relation of the random variable X to the random variable Y greatly facilitates the use of the lognormal distribution in analysis; once the parameters μ and σ^2 have been estimated, the logarithms of particular values of X may be used in reference to tables of the standard normal distribution. Therefore, the necessity of performing the integration indicated in expression (5) may be eliminated.

AN EXAMPLE OF THE USE OF THE LOGNORMAL DISTRIBUTION

The discussion of the previous section will now be illustrated with actual data from the public higher education system of Texas. Estimates of the components of the total expected contribution to higher education will first be considered. These results will be combined into a transformed lognormal description of the distribution of incomes of families of potential students in Texas; the results will be an approximation of the distribution of their expected economic contribution to the cost of higher education. This distribution will then be related to cost data in an example of its use in analysis.

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*J. Aitchison and J. A. C. Brown, "On Criteria for Descriptions of Income Distributions," Metroeconomica, Vol. VI, December 1954, p. 88.

Estimating the Ability to Pay

Data on the sources of student support would be valuable for estimating a student's ability to pay for higher education. Unfortunately, many public systems of higher education do not have access to this information; in such cases, other information may be used to develop estimates. For example, the College Student Questionnaire (CSQ) provides estimates of this information, as well as national norms for comparison with local results. This questionnaire was administered to freshmen at the University of Houston in the fall of 1966 and 1967 by Dr. Joseph P. Schnitzen with the results shown in Table 1.* Notice that the data from the University of Houston indicates a higher percentage of students who will rely on jobs as their "major source of support" than the national norm. Such results might be expected at an institution located in a large urban area where the lower cost of commuting encourages attendance from students from lower income families. This conjecture will be considered in more detail in the evaluation of results.

Loans and scholarships are reported as the major sources of student support for less than 15 percent of either the University of Houston freshman classes or the national norm. The apparent hesitancy of the average student to acquire a loan for his educational support may be due to a lack of available funds for this purpose, or to his reluctance to incur a debt due to the perceived risk related to the investment. In any case, the primary sources of student support seem to be parents and jobs (or personal savings, presumably the results of previous jobs).

An estimate of expected contribution by students toward their own higher education is difficult to obtain. It seems reasonable to expect college students in Texas to contribute, on the average, $325 from savings from summer earnings plus an additional $500 from one or more combinations of the following sources: previous savings, a long-term loan, or job earnings during the academic year (part-time

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*Joseph P. Schnitzen, "The University of Houston Freshman Class of 1967: A Descriptive Summary Based on the College Student Questionnaire--Part I," Counseling and Testing Service, University of Houston, Houston, Texas, May 1968.

Table 1

MAJOR SOURCE OF FINANCIAL SUPPORT REPORTED BY COLLEGE FRESHMEN RESPONDING TO THE COLLEGE STUDENT QUESTIONNAIRE (CSQ)

Major Source	University of Houston		National Norm Group (1965)
	1966	1967	
Parents	55%	52%	59%
Job	14	17	8
Scholarship	8	6	7
Loan	3	4	6
Previous Personal Savings	13	13	11
Other (ROTC, Insurance, etc.)	5	5	5
TOTAL	98%[a]	97%[a]	96%[a]

SOURCE: Joseph P. Schnitzen, "The University of Houston Freshman Class of 1967: A Descriptive Summary Based on the College Student Questionnaire--Part I," Counseling and Testing Service, University of Houston, Houston, Texas, May 1968.

[a]Percentages do not sum to 100 percent because of missing responses.

job).* The figure of $325 for summer jobs is the expected net profit from these jobs. All of these figures are estimates and "logical guesses," but will be used as approximations in this paper due to the lack of actual data. The need for research in this area is evident.

The estimation of parental contribution to the educational expenses of any particular student is impossible. Some families may be willing to bear extreme financial sacrifices so that their children may receive a higher education, while others are not. However, the College Entrance Examination Board has developed data for approximating the "expected" contribution of parents to their children's higher education based on their net income and size of family. The relevant data are reproduced in Fig. 1.

Family income data and national norm information are also available from the CSQ. However, more important than the income distribution of families of students currently attending institutions of higher education in a system is the distribution of incomes of families of potential students. Although no specific data on this question are available, a rough estimate of this income distribution can be made from the figures of the 1960 Census; the data include family income distributions by state and by age of the head of the family. The results of Table 2 were developed on the assumption that the age of the parents of most youths in the 18-24 year-old group would be from 40 to 50 years. Obviously, this data should be revised when the 1970 Census data become available.

This information may now be combined to develop a functional expression for the expected contribution to the cost of higher education by potential students within the State of Texas. The total expected contribution from scholarships and other sources was estimated to be $825. Further, Fig. 1 indicates that the expected contribution from a family of given size may be approximated a linear function of income. For example, the line expressing the relationship between expected contribution to a potential student's higher education and net income for a family with two dependent children passes through

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*John J. O'Hearne and Paul H. Kelly, A Survey of College Student Financial Aid in Texas, with Projected Needs Through 1980, a report to the Coordinating Board, Texas College and University System, April 30, 1968, p. 63.

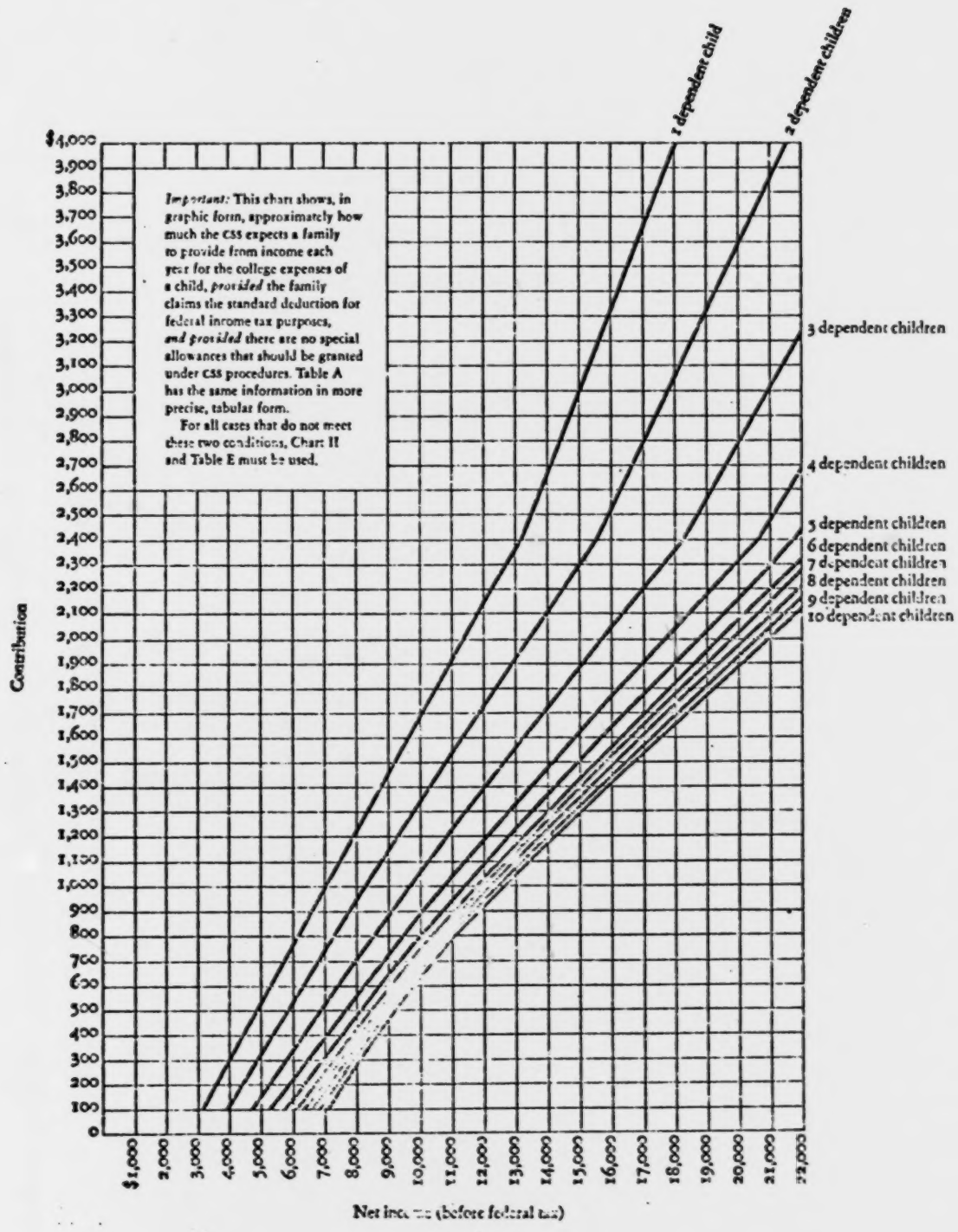

Fig. 1--Expected contribution from parents' net income (only for families with no allowance and with standard federal income tax deductions)

SOURCE: College Entrance Examination Board, Manual for Financial Aid Officers: 1967 Edition.

Table 2

ESTIMATED INCOME DISTRIBUTION OF PARENTS
OF POTENTIAL STUDENTS

Parental Income Before Taxes	Estimated Average Income	Estimated Percent of Families
Under $3,000	$ 2,500	15.0
$3,000 - 4,999	$ 4,000	17.0
$5,000 - 6,999	$ 6,000	20.5
$7,000 - 9,999	$ 8,000	25.0
$10,000 - 14,999	$12,000	15.0
$15,000 and Over	$17,000	7.5

SOURCE: U.S. Bureau of the Census, 1960 Census Report.

the points (100, 4000) and (2300, 15000), where the ordinate represents expected familial contribution and the abcissa represents income. The equation for the line connecting these points is

$$PC = .2(I) - 700 \tag{6}$$

where PC is defined as expected parental contribution. The substitution of these figures into eq. (4) results in the expression

$$\begin{aligned} EC_2 &= .2(I) - 700 + 825 \\ &= .2(I) + 125 \end{aligned} \tag{7}$$

where the subscript 2 denotes family size.

This expression may be used in its present form for crude approximations to the expected contribution to the cost of higher education by potential students. For example, the data of Table 2 indicate that approximately 30 percent of the potential students in Texas are from families whose income is $4000 or less. Assuming that the same percentages are reasonable approximations for families with two dependent children, the use of the preceding formula indicates that potential students from these families can afford to pay no more than approximately $925 per year for higher education. Recall that this figure is an aggregate, which may be thought of as being derived from psuedo-Engels curves associated with families with similar economic situations.

The expression for the expected contribution may be made more explicit by using a lognormal distribution as a statistical description of this income distribution. The two parameters of the lognormal distribution, μ and σ^2, may be estimated from empirical data, grouped or ungrouped, by several techniques, including the method of maximum likelihood, the method of moments, and the method of quantiles.* As an example, the income data from Table 2 were used to estimate

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*J. Aitchison and J. A. C. Brown, The Lognormal Distribution, The University Press, Cambridge, 1957, pp. 39-40.

these parameters by the method of maximum likelihood. The formulae are

$$m = \frac{1}{n} \sum_{i=1}^{n} \log x_i, \quad \text{and} \tag{8}$$

$$s^2 = \frac{1}{n} \sum_{i=1}^{n} (\log x_i - m)^2 \tag{9}$$

where m and s^2 are estimates of μ and σ^2, respectively. The results were m = 3.80149 and s^2 = .05929. A chi-square goodness-of-fit test was performed which indicated that the resulting approximation differs from the expected result of a chance agreement at the .05 level.

This information permits the derivation of the distribution function for "expected contribution." In particular, the distribution function of the variable Y = a + bX, where X is a random variable with distribution function $F_X(x)$, is given by

$$F_{aX+b}(x) = P[aX + b \leq y] = P[X \leq \frac{y - b}{a}] = F_X(\frac{y - b}{a})^* \tag{10}$$

Therefore, the distribution function of "expected contribution" is given by

$$F_I(\frac{x_2 - 125}{.2}),$$

where F_I is the distribution function of income and x_2 is the total expected contribution for a family with two dependent children.

There are several possible approaches for obtaining a similar distribution function for the entire population of the State. Similar functions for each family size could be developed, and a weighted sum could be used. Unfortunately, the sum of two random variables with lognormal distributions results in a distribution which is not easily amenable to analysis. Another alternative is to assume an "average"

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*Emanuel Parzen, Modern Probability Theory and Its Applications, John Wiley & Sons, Inc., New York, 1960.

family size and approximate the distribution function as previously described. The discussion which follows will assume that the latter alternative was adopted with a family size of two dependent children selected as representative.

A Comparison with the Costs of Higher Education

This section will illustrate the development of cost data relevant to the analysis of policy decisions in higher education. This information will be combined with the lognormal distribution function developed in the preceding section to illustrate its use.

Identification of average student costs for different types of institutions of higher education under different circumstances with respect to the student's status is still primarily guesswork in most states. For example, such data for institutions of higher education in Texas are not complete. Reasonable estimates of costs are available for students residing on campus in school regulated dormitories. The colleges and universities publish their charges for tuition and fees, and room and board. In addition, the Coordinating Board of Texas has established "maximums" for most of the remaining items. However, for commuting students and especially for married students, data on costs are difficult to identify with confidence. Thus, the major emphasis of this paper will be on the consideration of the cost of higher education to the single student, even though the percentage of married students attending public institutions of higher education has increased in the past few years. The average expense budgets for single students residing on campus and for single commuting students in Texas appear in Table 3.

This information may now be combined with the transformed lognormal distribution with parameters $m = 3.80149$ and $s^2 = .05929$ which was developed in the preceding section. The proportion of potential students in Texas who can be expected to contribute $2418 for living in residence at a non-public four-year college may be estimated from:

Table 3

ADJUSTED EXPENSE BUDGETS FOR SINGLE STUDENTS IN TEXAS

	2-Year Colleges		4-Year Colleges	
	Public	Non-Public	Public	Non-Public
Adjusted Total Budget for Students Residing on Campus	$1,671	$1,929	$1,723	$2,418
Adjusted Total Budget for Commuting Students	$1,411	$1,697	$1,325	$2,054

SOURCE: John J. O'Hearne and H. Paul Kelley, "A Survey of College Student Financial Aid in Texas with Projected Needs Through 1980," A report to the Coordinating Board, Texas College and University System, April 30, 1968; and James S. Dyer, Cost-Effectiveness Analysis for a Public System of Higher Education, unpublished Ph.D. dissertation, The University of Texas at Austin, August 1969.

$$F_I\left(\frac{x_2 - 125}{.2}\right) = F_I\left(\frac{2418 - 125}{.2}\right)$$

$$= F_I(11465)$$

The logarithm of 11465 is 4.05937. The standard normal tables may be used from the result of the expression

$$z = \frac{x - m}{s}$$

$$= \frac{4.05937 - 3.80149}{.2435}$$

$$= 1.059.$$

The area under the standard normal curve which corresponds to this value is .855. This figure represents the proportion of potential students in higher education in Texas who cannot be expected to pay the cost of living in residence at a non-public four-year college. Similar analysis reveals that 77.4 percent, 66.1 percent, and 49.9 percent cannot be expected to afford the cost of non-public commuting, public in-residence, and public commuting higher education. Although these figures may seem high, less than 50 percent of the potential students in Texas actually enroll in institutions of higher education.

The effects of policies affecting the costs of higher education can be evaluated in a similar manner. For example, the increase or decrease in the actual number of potential students who are not "priced out" of the system would be revealed by

$$N\left(F_I\left(\frac{c_1 - 125}{.2}\right) - F_I\left(\frac{c_2 - 125}{.2}\right)\right) \qquad (11)$$

where c_1 and c_2 represent the estimated total costs of higher education to the student under two different alternatives, and N is an estimate of the total number of potential students who would be affected. The use of this technique revealed that the total enrollment in the public system of higher education in Texas would be increased by an estimated 16 percent if four-year public institutions of higher education were

established in Fort Worth, Dallas, San Antonio, and Corpus Christi.* In a similar manner, projections of future state income distributions could be used to analyze the impact of changing costs of education over longer time horizons.

In addition, George B. Weathersby has shown that the derivation of a distribution function for enrollment as a function of cost would allow the analytic study of optimal tuition rates for private and public institutions of higher education.** The distribution function developed in this paper is not equivalent to the proposed Weathersby model. However, representing "expected contribution" of potential students, it may form the basis for such a model via an additional transformation.

CONCLUSIONS

This analysis has demonstrated the potential usefulness of a transformed lognormal description of income data in the analysis of policies related to altering the cost of higher education to the student. The form of the proposed model was first presented. The use of the approach was illustrated with data from the State of Texas.

Several limitations were noted. A primary problem involved the lack of adequate data. A more serious consideration with respect to the proposed methodology is the problem of combining the estimated distributions of contributions for families of different sizes. In addition, further research would be required to determine the feasibility of transforming the model into a distribution function of actual enrollment as a function of costs.

Despite these limitations, this approach does appear valuable for estimating the effects of proposed changes in the cost of higher education. These effects could be combined with other data to develop "cost-effectiveness" information particularly relevant to planners of a state's educational system.

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*Dyer, op. cit.

**George B. Weathersby, "Student Tuition Models in Private and Public Higher Education," Office of Analytical Studies, The University of California, Berkeley, December 9, 1969.

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